REPORT OF STUDY
OF
BOILER FACTORS IN REGARD
TO
INDECK KEYSTONE ENERGY
V.
VICTORY ENERGY OPERATIONS

Robert V. Seibel
RMR Technical Services, Inc.
5650 Gardner Drive
Erie, PA 16509

Submitted: September 12, 2006

Report of Study of Boiler Factors in regard to Indeck Keystone Energy v. Victory Energy Operations

Organization of Report:

Included with this report:

Report of Study of Boiler Factors in regard to Indeck Keystone Energy v. Victory Energy Operations

Section 1 - Robert V. Seibel - Personal Information

1.1 Employment Summary:

Currently I am self employed doing business as RMR Technical Services, Erie, PA. From 1967 until retirement in 1996 I was employed by Erie City Iron Works, later known as the Energy Division of Zurn Industries, Inc. (“Energy Division.”) From 1954 until 1967 I was employed by the Babcock and Wilcox Company, Barberton, OH.

A detailed work history/career profile is attached in Attachment 1.

1.2 Summary of Recent Legal work:

Currently I am consulting with Zurn Corporation (Now known as Jacuzzi Products), Zurn’s insurers and Zurn’s national and local legal counsel in connection with the defense of various asbestos cases filed against Zurn relating to its boiler products. I have testified by deposition three times in the past four years in connection with asbestos cases.

The three cases are outlined in Attachment 2.

1.3 Documents that Reviewed and Studied:

Several documents were presented to me and were reviewed and studied in order to make findings that could be pertinent in this case.

Documents that were reviewed are listed in Attachment 3

Report of Study of Boiler Factors in regard to
Indeck Keystone Energy v. Victory Energy Operations

Section 2 - Background to Boiler Industry

It is important to discuss and understand certain critical points about a boiler, its purpose, customer expectations and design methods. That discussion will develop background about the use of licensed and confidential information.

2.1 What is a Boiler?:

A boiler is a means to convert intrinsic energy in a fuel (energy that is available when a fuel is burned) into a form of thermal energy that can be transmitted and used remotely.

To do this, a boiler will allow the safe and ready combustion of a fuel to release heat. Heat from combustion is absorbed into water transforming water to steam. Steam flows through a system of pipes to where the steam can be used for space heating, process heating or in a turbine that will drive an electrical power generator or supply power to drive a pump, fan or compressor. A boiler has no purpose other than to supply steam to a process or turbine. The capabilities of a boiler are never needed alone.

2.2 Boiler System:

To operate, a boiler must be connected into ancillary systems including: a fuel system that will safely handle and regulate fuel flow; a fuel burner that will mix fuel with a stream of air; a combustion air system to provide and regulate air flow to the burner; a water system that provides properly treated water at sufficient pressure; a combustion gas exhaust system and exhaust stack; a system that may have to control emission of pollutants from combustion of the fuel; a system of pipes and valves that connect the boiler to the process; and, a system of pressure temperature and flow senors and controls that will allow matching the rate of fuel combustion and steam generation to process needs and insure the safe operation of the boiler.

In most cases, to complement the process that requires steam, a boiler is expected to be able to operate continuously for weeks and months without unpredicted shutdowns and maintenance downtime.

2.3 Buyers' Interests:

When a boiler is needed for a process the process designer and operator will have certain criteria in judging the comparative worth of different boiler designs that could be applied. In purchasing a boiler to be integrated into a process, the process designer/operator will evaluate purchase price, installation costs, operational and maintenance costs for the various designs offered by boiler manufacturers. The designer/operator will also judge the worth of unique and extra cost features that are offered.

In the evaluation process, the designer/operator who decide the purchase, will attempt to develop confidence that the boiler manufacturer is credible in making the claims and presenting design and workmanship guarantees.

Usually the cost of the boiler will be only a fraction of the cost of the total process. In making the purchase decision, the process designer/operator attempt as much as possible to prevent the boiler from being the "weak link" in the successful operation and in obtaining the expected profitability of the process.

In some cases the boiler supplier is assumed to have sufficient experience with the boiler design but it is typical for a boiler suppler to be asked to demonstrate and document experience with similar installations and applications. In the marketplace, a boiler design that has a long history will be more readily accepted by a buyer.

2.4 Worth of a Boiler Design:

A proven boiler design with a documented history of successful installations can have substantial monetary value to a boiler manufacturer. For various reasons such as redefined market interests or manufacturing costs, proven boiler designs are sometimes made available to other boiler manufacturers by license to design and build or by selling all intellectual (i.e., computer software, design manuals) and real assets (i.e., fabrication drawings) that encompass the design.

Report of Study of Boiler Factors in regard to
Indeck Keystone Energy v. Victory Energy Operations

2.5 Boiler Design:

A boiler consists of a means to burn fuel and a system of tubes and drums that transfer heat from combustion into water converting the water into steam. There are two parts to a boiler: the combustion chamber - sometimes called the furnace and the boiler section. Fuel and combustion air are injected into the combustion chamber where the fuel is burned generating high temperature flue gas. The flue gas flows into the boiler section where heat from the hot gas is transferred and absorbed into water. The combustion camber and boiler section are enclosed in the boiler setting that isolates the high temperatures inside the boiler and maintained safe temperatures on the outside.

There are two types of boilers:

> **Firetube boilers** where flue gas flows through tubes transferring heat to water outside of the tubes. The tubes are contained in a drum that is partially filled with water. Steam generated rises to the top of the drum where it is collected to be transported to the process.
>
> **Water tube boilers** where combustion gases flow around the outside of the tubes. Heat is transferred to water inside of the tubes generating steam. The tubes are connected into a drum so that water and steam flow into the drum. The water is collected at the bottom of the drum and is returned to the bottom of the tubes. Steam is collected at the top of the drum where it will flow to the process.

A boiler is a piece of equipment consisting of hundreds of parts including tubes, drums, pipes, steel plates, structural components, insulation and refractory each of which is specifically designed and fabricated. The parts are then assembled according to an overall plan.

The primary purposes of a boiler are to burn a fuel and then transfer the heat from combustion into water and steam. Water and steam containing parts of a boiler are called the “pressure parts.” The pressure parts are heavy and a critical design of the boiler is the structure that is required to support the pressure parts. In operation the

temperature of pressure parts and some parts of the structure may be several hundreds of degrees and represent a personnel safety hazard. The outside of the boiler must be insulated to make it safe.

The first step in designing a boiler is to determine the required size of the combustion chamber. A burner refers to the equipment that mixes fuel and air as they enter the combustion chamber and has the characteristic that when a flame is established at the discharge of the burner, the point where fuel will ignite is constant. The ignited fuel and combustion air will continue to burn is the combustion chamber but completing combustion will take some from a fraction of a second for natural gas to several seconds for a coal or wood.

The residence time for complete combustion will determine the size of the combustion chamber. Because combustion temperature will be greater than 2500 degrees (combustion temperatures are so high that the flame cannot be observed without using darken eye protection) the materials of construction of the combustion chamber walls must be refractory or water cooled in some way. It has become common practice that the combustion chamber walls will be made up of boiler tubes that are part of the steam generation system. By having the combustion chamber "water cooled" has meant that boiler reliability will be greater and there will be less maintenance compared to refractory designs.

Heat transfer into the furnace walls will be by radiant heat transfer - similar to how the sun heats the earth.

The next step in boiler design is to design the boiler section where combustion gases are cooled by generating steam. For a water tube boiler an array of tubes is designed so that hot flue gas is directed over the tubes in a way that enhances turbulence and at speeds (velocities) to obtain predictable rates of heat transfer. The designer will determine the length of tubes, the number of tubes that are required and how the tubes are arranged (in-line or staggered.)

Heat transfer in the boiler section will be by convective heat transfer.

The designer will plan to have flue gas cooled to about 100 to 200 degrees above saturation temperature at the boiler's operating pressure. For example, if the boiler

operating pressure is 150 pounds per square inch, saturation temperature will be 365 degrees. The designer may design the boiler section to cool gases to 565 degrees.

2.6 Heat Transfer Design:

Since water tube boilers have been designed for more than 100 years, a designer starts with a design in mind and in most cases will "rate" (determine the performance) of a boiler design that has been used before using the requirements of the particular application.

Heat transfer methods that are used in boiler design will follow classical methods which correlate radiant absorption and convective heat transfer. Radiant absorption will account for radiating characteristics of combustion gases which vary depending on the amount of radiating gasses such as water vapor and carbon dioxide and the characteristic of the "receiving" surface.

Convective heat transfer methods will correlate the velocity of gases over the tubes varying with the gas physical properties, turbulence and mixing that is caused by the tubes.

In both radiant heat transfer and convective heat transfer for boilers the classical methods are modified by "fudge" factors that are developed by studying the performance of similar designs. Heat transfer correlations for boilers are "empirical" meaning that they have been checked and can be modified by the test results. Typically, empirical relationships for heat transfer are closely held and may be identified as confidential by a boiler manufacturer.

2.7 Pressure Part Design:

In operation a boiler can be very dangerous because it holds substantial quantities of very hot water at the steam pressure. If a leak or some fault occurs in a boiler's pressure parts there can be a sudden and very destructive release of energy.

In the early part of the last century - 1900s- the boiler Industry was evolving with little commonality in regard to minimum design for safety of boiler pressure parts.

Report of Study of Boiler Factors in regard to
Indeck Keystone Energy v. Victory Energy Operations

In the interest of the common good, The American Society of Mechanical Engineers (ASME) took on the responsibility of devising and overseeing a Boiler Code that would set design rules for boilers. The ASME Boiler Code is still administered by the members of ASME with the responsibility divided among pertinent lines of committees and sub committees. The Boiler Code has grown in scope and has narrowed in options that can be used for designing pressure parts of a boiler.

A qualified boiler manufacturer will be authorized to "stamp" a boiler's pressure parts as having been designed and fabricated in accordance the ASME Boiler Code. Today the Code is accepted by all states and by some foreign countries as the standard for licensing a boiler to operate.

2.8 Structural Design:

When assembled a boiler can weigh more than 100 tons. Within the boilers arrangement of pressure parts there will be heavy pieces that must be supported and the weight of the pieces must be transferred through the boiler's structure to the foundation. Depending on the capacity and physical size of the boiler it can either be shop assembled or field erected. Shop assembled means that the boiler is completely assembled in the shop and received on site as a single piece. For a boiler that would be too large to be shipped assembled it is field erected. Boiler parts are shipped individually to the site where they are assembled.

As boiler designs have evolved, shop assembled units have become more important in the marketplace. Capacity of shop-assembled units have increased along with operating pressure. There is also an interest to deliver boilers that are less expensive but at the same time are reliable with minimum maintenance. Shop-assembled units are more important for "clean" fuels such as natural gas and light weight oil (similar to kerosene or diesel fuel.)

Structural designs for shop-assembled units will integrate (combine) structural aspects with the boiler setting. For example, the outer casing which serves as the gas pressure containment of the boiler setting can be supplemented to transfer the weight of pressure parts into the foundation. There are clear design aspects for support in a shop-assembled boiler. The upper drum which is the greatest weight of

the boiler may not be solely supported by furnace or boiler bank tubes. The front and rear casing of a shop-assembled boiler may have to be designed based on the weight of the upper drum.

For shop-assembled units, the structural aspects of the boiler as it operates on its foundation may not be the controlling factor for adequate design. Shipping a boiler by rail or truck or over water may impose much greater loads. On a rail car, the boiler may be subjected to several times the forces of gravity as the rail car is “started” or is “humped.” The front to rear or side to side forces imposed in shipment is different from those when the boiler is on its foundation. Experience in building and shipping shop-assembled boilers is the only way to prove the design of the base that contacts the foundation and how the base is integrated into the other parts of the boiler structure.

2.9 Shop-assembled Boilers:

Shop-assembled boiler designs have evolved in logical ways. The variable of boiler design that allows the greater combustion chamber volume and greater amount of boiler section convection section is boiler length. Shop assembled units are limited in overall width and height but length can be varied to comply with combustion chamber and boiler section requirements. To facilitate using length, shop-assembled boilers will have drums that run the length of the boiler - longitudinally. All shop-assembled boilers that are offered in the marketplace are longitudinal drum boilers.

The cross sections of the various designs remind one of a letter such as “A,” “D,” or “O.” Each design strives to deliver the most capacity with the more facilitated shipping and delivery and with features that provides reliable service and acceptable maintenance. All designs have years of application experience.

> *For example, the IKE Keystone Steam Generator was first designed and built in 1950. Since that time more than two thousand Keystone boilers have been delivered and operated. This would mean that there have been more than forty thousand years of operating experience with Keystone Steam Generators.*

Competitive influences in the boiler market have spawned ways to increase the capacity, reliability and reduced maintenance of boilers that can be shop-assembled. The utilization of the maximum amount of water-cooled furnace and out walls and the elimination of refractory applied at high temperatures have been the principal direction of boiler design. In line with increased capacities, burner manufactures have developed burner designs that are more effective and now burners that will have reduced emissions of combustion generated pollutants.

Boiler designs such as “O” and “A” boilers are symmetrical around the center. For shipping, the symmetrical design is important since the center of gravity will be at the center of the boiler. This means that there is no need for some means to balance the off-center load of a “D” design. It follows that the “A” and “O” design with greater capacity and which are heavier can be shipped shop-assembled.

2.10 Steam and Water Circulation:

In a water tube boiler there must be water flow through the tubes at rates sufficient to cool the tubes as heat is absorbed and water is converted to steam. If there is not enough flow, the tubes may not be cooled sufficiently and can be overheated and fail. The process of recirculating water through the tubes is called boiler circulation. There are thermodynamic characteristics causing boiler circulation that relates to operating pressure of the boiler. At lower steam pressure - less than 400 pounds per square inch - circulation will be greater but at higher steam pressures circulation will be increasingly limited.

Circulation is caused by the difference in the weight of water in the tubes that return water top the lower end of steam generating tubes and those tubes where steam is being generated and there is a mixture of steam and water. The difference in density will cause steam and water to flow into the upper drum where the steam will collect at the top of the drum and water, being heavier, will collect at the bottom of the drum. Tubes from the bottom of the drum return water to the lower drum and to the inlet of steam generating tubes. In a water tube boiler the amount of recirculated water will be 10 to 40 times the amount of steam that is transmitted to the process.

An important duty of the steam drum is to effectively separate steam from water

flowing into the drum from steam generating tubes. Most steam using processes require steam that has little or no water being carried along with the steam (carryover.) Water in steam can collect and interrupt flow and cause a "water hammer" in the pipes that connect the boiler with the process.

Most boiler manufacturers have devised devices that are installed in the steam drum which will separate steam from water (steam separators) and also other devices (steam scrubbers) that remove trace amounts of water so that steam leaving the drum will be 100% steam (i.e., 100% Steam Quality.)

In the steam drum the steam separators are connected at the discharge of the steam generating tubes. In that position, they will impose a resistance to flow from the steam generating tubes. If not properly designed using a thermodynamic analysis of circulation forces, flow through the steam generating tubes can be impeded affecting the safety of the steam generating tubes.

On the other hand it can be shown that steam separators can be positioned to isolate steam generating tubes that may not have strong circulation forces. In these cases steam separators can be used to enhance circulation to assure safety of operation. Shop-assembled boilers have limited dimensions so that the circulation capability is usually limited. For furnace wall tubes which are exposed to combustion gas temperatures more than 2,500 degrees, the boiler designer must analyze circulation and make design choices as to how steam separators are to be used in the steam drum.

Report of Study of Boiler Factors in regard to
Indeck Keystone Energy v. Victory Energy Operations

Section 3 - Development of Keystone Steam Generators

The Keystone Steam Generator was first offered by Erie City Iron Works - now known as Indeck Keystone Energy - in 1950. The Keystone Steam Generator, an "O" type, water tube boiler, was developed in response to boiler market demand for greater capacity shop-assembled boilers utilizing clean fuels (natural gas and oil.)

> *Erie City Iron Works was a company that first did business in Erie in 1840. Its history can be traced more than 150 years and as such Erie City Iron Works would be the oldest, continuously operating boiler company in the United States.*
>
> *As its business and market interests evolved it became focused on boiler needs of Industry - rather than central power station boilers for electrical power generation. (Industrial Boilers are generally lower steaming capacities and lower steam pressures than boilers for power generation.)*
>
> *In 1950, market interests led to developing The Keystone Steam Generator. At the time, Erie City Iron Works was offering shop-assembled units for clean fuels but the designs had limited steaming capacity. The products did not meet customer expectations.*

3.1 Acceptance of Keystone Steam Generators:

When the Keystone Steam Generator was developed Erie City Iron Woks had a long history of being a boiler designer for all sorts of boiler designs. In fact, the company had been in business for nearly one hundred years. The Keystone Steam Generator design drew upon data and broad operating experience with its other products.

From the first unit until now, nearly three thousand Keystone units have been designed and fabricated. (For boilers, there are no definite life factors if they are well maintained and carefully operated. It is estimated that more than one-half of the Keystone Steam Generators that have been built still operating.)

The Keystone Steam Generator was first designed and built in 1950. Since that time more than two thousand Keystone boilers have been delivered and operated. This would mean that there have been more than forty thousand years of operating experience with Keystone Steam Generators.

Focusing on the Industrial boiler needs led to design features that make the boiler easier to inspect and maintain and to have lower maintenance.

For example:

Keystone Steam Generator tube arrangements call for an access cavity inside - which other designs do not have - that facilitates inspection of the boiler section.

Keystone Steam Generators were the first shop assembled boilers to have optional water cooled front and rear welded walls to eliminate limited service life, refractory constructions. (Welded front and rear walls were developed more than 30 years ago.)

Keystone Steam Generators have the advantage of having the center of gravity on the boiler centerline and a structure that is integrated with the pressure parts. To facilitate lifting and installation, Keystone Steam Generators have always had lifting lugs are welded onto the steam drum , at the top of the boiler. (Early designs of other shop assembled designs did not feature lifting from the top.)

Keystone Steam Generators are an all-welded, gas tight unit that is bubble tested in the shop. Shop assembly procedures call for the entire length of all seal weld seams to be “soap bubble” checked when the boiler is pressurized with air.

3.2 Keystone Steam Generator Versatility:

The Keystone Steam Generator design has proved to be exceptionally versatile. The capacity of shop-assembled units has grown by finding ways to ship larger and larger

units. The maximum capacity of shop-assembled Keystone Steam Generators has increased nearly ten fold from the first units.

To serve market interest for Industrial Boilers, Erie City Iron Works, Zurn Energy (now IKE) has maintained a significant engineering capability. In this way, the company was ready to extrapolate the application of its products top meet special needs.

There are numerous special applications of Keystone Steam Generators to burn unusual fuels, to operate at unusual steam conditions and in different from standard configurations.

3.3 Design Evolution

Many Keystone Steam Generator design features have changed as operating experience has been gathered and customer expectations have changed.

For example:

> By far the greater number of Keystone Steam Generator settings have been designed and fabricated using a combination of refractory and insulation for front wall and tube and refractory tile and insulation rear wall and tangent tube and welded seal casing design for outer walls. Operating experience have proved these designs capable of long term reliable operation.
>
> Where materials of construction have not had acceptable service life, designs have evolved that decrease temperature stresses in the walls or that utilize newer insulating and refractory materials.

The last substantial design changes to the standard Keystone Steam Generator setting design were made more than 30 years ago and have the advantage of lesser cost but without sacrifice of reliability.

In another case, as experiences with Keystone Steam Generator were gathered it was found that the rigors of shipment required strengthening the front and rear casing as

the boilers are fastened on the rail cars. Dynamic loads during shipment are in front to rear direction and occur at the plane of the top of the car where the boiler is tied to

the car. First Keystone bases were built for convenience of pre-assembly but it was found that the front and rear boiler supports had to be more integrated with boiler pressure parts.

3.4 Important Variations in Design

Over the life of the Keystone Steam Generators, customer expectations have changed. There has been a growing interest to eliminate all refractory construction that could require any maintenance to have adequate reliability.

This has led to the development of designs using welded tube panels.

In this design tubes are installed with a bar welded to each adjacent tube. The construction eliminates the need for a seal casing. Refractory cannot be completely eliminated but the design requires only small amounts of refractory that is packed around the necessary penetrations though the boiler setting. The required refractory will not need routine maintenance nor replacement for preventative maintenance.

The first welded walls were applied in 1972. Since then more than 300 Keystone Steam Generators have been equipped with welded front and/or rear walls.

3.5 Keystone Steam Generator Superheaters:

An important aspect of Industrial boilers is the requirement to further heat (superheat) steam. In this way more usable energy can be extracted from the steam where it is used. A “superheater” is installed so that some of the heat from combustion is transferred to steam from the boiler increasing its temperature.

Erie City Iron Works had much experience in applying superheater to its other boiler products, so Keystone Steam Generators were equipped with superheater to meet process requirements. It was decided the superheater should be unique in its

performance. The designer can decide whether to emphasize radiant or convective heat transfer. Emphasizing radiant heat transfer will result in a more constant steam temperature over a range of steaming rates. (Other boiler manufacturers do not offer "radiant" superheaters.)

When operating experiences and the service life of Keystone Steam Generator superheaters was observed, the fundamental design was changed while retaining the "radiant" characteristic. The change occurred in 1965 so that there have been more than 40 years of experience with the current design.

Report of Study of Boiler Factors in regard to
Indeck Keystone Energy v. Victory Energy Operations

Section 4 - Product Development

The boiler industry has always been competitive, meaning that for the typical standard application of a boiler the buyer can solicit proposals from several manufacturers will offer their design. Each manufacturer will develop application information and data that will closely comply with the buyer's specifications. Boiler manufacturers will develop the best price for the proposed equipment and where possible offer special features or options that will in some benefit the buyer. In the end competition is keen and profit margins are well controlled.

Since boiler buyers must be confident that the boiler will perform as required to complement the process, they are critical of untested, unproven designs. A company desiring to compete with existing boiler designers/manufacturers who can offer proven designs must either obtain the rights to offer existing, proven designs or develop their own design.

To develop a new, acceptable, competitive boiler product the company must perform a comprehensive analysis of existing designs, build an operating prototype of the new boiler and then perform documented performance testing that will demonstrate adequate capability and specified, guaranteed performance. The development of a new design that will be competitive is a lengthy process. From beginning of the design process to when an acceptable design could be offered for sale could take over a year.

Obtaining the rights to a proven design could shortcut the process.

Besides the required time, an effort to develop a new line of boilers will incur significant cost - perhaps several times the cost of a prototype. The reality of the boiler industry - which can be said to be mature - is that cost of a new line of boilers is not a good investment.

4.1 Economic Factors:

The competitive situation means that there are little margins that can be used for

product development or research. A manufacturer must interpolate and extrapolate experiences to develop new designs. The boiler market will not support the extensive development costs for new designs since profit margins will not provide sufficient return on investment.

4.2 Design Requirements:

Economic consequences of not meeting performance warranties and guarantees are so great that there must be direct experience in the boiler's operation. If a new design boiler were to be devised, there must be field testing of a prototype to confirm performance factors.

4.3 Testing a New Design:

In order to test a new design boiler, it would be necessary to find a site where the boiler could be installed. One significant factor in boiler testing is that liability for boiler operation would have to be covered by the company that would benefit from the testing. Proper testing requires loads to be adjusted to test conditions. Testing requires oversight by personnel. Test equipment that would provide comprehensive data would have to be installed. When gathered the test data would have to be analyzed and evaluated in regard to predicted to develop the empirical relationships.

4.4 Reverse Engineering:

Inspecting an existing boiler, finding its physical dimensions and features and observing its operation in most cases would not be sufficient for a boiler buyer to commit to a new, untested design. The boiler buyer expects reliable, predictable performance from the boiler in support of the buyer's process. Even having the most favorable cost will not be accepted. Typically a buyer will overlook the lowest first cost equipment unless there is valid documented results of other installations.

4.5 Determining Heat Transfer Factors:

Boiler sales are technically based. In that regard it appears that designer/manufacturer publish munch data that pertain to their boiler products. The

data is useful in the general sense since it will allow a buyer to “fit” the boiler into the space available and to determine preliminary installation dimensions. To purchase a boiler, there will be communications between the buyers and the boiler designer. For example the fuel analysis, operating conditions, environmental consideration, allowable emission will be unique to the application.

In response to a request for a proposal, the boiler designer will offer a design which is intended to best meet the specifications. A boiler proposal will include overall performance of the proposed design but will not give information about heat transfer coefficients and “fudge” factors that have been found from experience. Empirical design information is closely held and not disclosed by any boiler designer.

For a new line of boiler designs, in light of economic factors it may be attractive to use classical heat transfer relationships. The reality is that classical relationships cannot account for the actual conditions within a boiler. There are manufacturing tolerances that must be considered, “dirtiness” of heat transfer surfaces and resistance to heat flow that must be evaluated and effects of gas flow distribution due to mal-distributions from burners and effects on flow distribution from the real conditions.

Over a line of different capacity boilers there has to be empirical means to be able to interpolate or extrapolate boiler performance. Over a range of sizes with standardized dimensions, there has to be empirical relationships, found by testing, used to modify the classical techniques.

The importance of having tested heat transfer cannot be understated. Heat transfer will determine how much heat will be absorbed in the boiler. This stated as “thermal efficiency.” Boiler efficiency will determine how much fuel is required to generate the steam needed for the process.

> *The most common boiler contractual guarantee is boiler efficiency. If the efficiency guarantee was not met, fuel flow would be greater than expected. Since the cost of having greater than guaranteed fuel flow over the life of the boiler is so great - many times the cost of the boiler - that there has never been a monetary settlement. Instead corrections to boiler equipment have always been made to satisfy efficiency guarantees.*

4.6 Closely Held Information:

Boiler designer/manufacturers will present much information in their sales brochures, but do reveal critical factors. Not shown are empirical radiant and convective heat transfer factors used to determine performance of heat transfer in the combustion chamber, a superheater, boiler sections and heat traps.

After the sale a boiler designer will produce assembly and installation drawings and information to allow operator training and maintenance. However, to secure spare parts business, information and drawings relating to a boiler's pressure parts will be closely held and not released. Also, design and application information about steam separators and steam scrubbers installed in stream drums will not be published.

Information That Is Offered by Boiler Designer/manufacturers for Selling Purposes:

Standard Product Physical Dimensions , Outside and Overall Dimensions of Length, Width, Height and Weight
Standard Product Steam Generation Ratings for "Standard" Fuels
Proposal data and calculation results to demonstrate compliance with specification

Information That Is Given by Boiler Designer/manufacturers to Users for Training and Maintenance:

Arrangement and Assembly Drawings
Recommenced Spare Parts List
Operating Instructions and Safety Warnings
Ancillary Equipment Vendor Operating Instructions
ASME Pressure Vessel Data Reports and Evidence of ASME Boiler Code Compliance
Selected Predicted Performance Data

Report of Study of Boiler Factors in regard to
Indeck Keystone Energy v. Victory Energy Operations

Information That Is Closely Held by Boiler Designer/manufacturers:

Fabrication (Shop) Drawings
Bills of Material - Material Lists
Radiant and Convective Heat Transfer Factors and Relationships
Comprehensive Performance Factors and Calculated Values
Design Software
Radiographs and Quality Assurance Reports
Labor and Material Costs
Manufacturing Process Capability

Report of Study of Boiler Factors in regard to
Indeck Keystone Energy v. Victory Energy Operations

Section 5 - Findings:

In reviewing the information as listed below that has been submitted by the plaintiff, IKE and the defendant, VEO, it was found that:

5.1 An empirical heat transfer factor described in IKE Keystone Design Manual was passed along to the VEO vendor.

5.2 Information presented by VEO for projects where VEO will supply its "VS" boiler designs is not complete and is insufficient.

Complete information including drawings and Material Lists for casing, tube arrangements, structural elements, drum internals and refractory, tile and insulation that are to be used for fabrication and assembly must be obtained to understand and to fully compare the VEO "VS" design to IKE Keystone Steam Generator design.

5.3 VEO drawings depicting design of Lifting Lugs on the Upper Drum boiler for VEO "VS" products show details identical to IKE Keystone Steam Generators.

Design of lugs shown on the VEO drawings is identical to IKE drawings.

Welding specifications shown on the VEO drawings are identical to IKE drawings.

5.4 VEO drawings depicting design of Front and Rear Wall Tubes for VEO "VS" products show details identical to IKE Keystone Steam Generators.

Layout of welded front and rear walls tubes is identical to IKE Keystone Steam Generator design.

Welded front and rear wall tube bending specifications are identical to IKE Keystone Steam Generator design.

Report of Study of Boiler Factors in regard to
Indeck Keystone Energy v. Victory Energy Operations

5.5 VEO drawings depicting design of Rear Wall Access Doors for VEO "VS" products show details identical to IKE Keystone Steam Generators.

The location where the bottom of the opening is level with the outer wall tube.

Design and tube layout for the rear wall access door is identical to IKE Keystone Steam Generator design.

5.6 VEO drawings depicting design of Outer Wall Tubes for VEO "VS" products show details identical to IKE Keystone Steam Generators.

The "Typical Section" view is identical to IKE design.

5.7 VEO has offered many sales brochures and product in formatives as evidence that a new boiler design can be taken from exiting information in the public domain.

Review of the information shows that much dimensional data about boiler products are offered and pictorial "cuts" of construction detail are made public. However, there is:

No information specific enough to determine heat transfer performance.

Not enough information to allow fabrication of parts.

Not enough information to allow total assembly of boiler parts.

Report of Study of Boiler Factors in regard to
Indeck Keystone Energy v. Victory Energy Operations

5.8 Given the difficulty and vast amount of time and expense required to develop a new boiler design (the IKE Keystone Steam Generator designs draw upon more than 100 years of boiler design and operating experience), VEO could not have created the "VS" boiler design without copying IKE Keystone Steam Generator drawings and design information.

That VEO passed along IKE empirical information to a vendor proves this.

o o o OO o o o

Robert V. Seibel

Attachments

EDUCATION:

Bachelor of Science - 1954 Pennsylvania State University, University Park, PA

PROFESSIONAL EXPERIENCE:

Presently Self Employed - RMR Technical Services, Erie, PA

Work included:

- Consulting with Aalborg Industries (*successor to Zurn Energy Division*) doing special boiler Engineering Projects in the home office and on site, Development of Operator Training Aids and Operating Instructions.

- Development of Steam Separation and Steam Scrubber retrofit application for two process steam systems in a West Coast Refinery.

- Design of an Induced Flue Gas Recirculation System for a Gas Fired Boiler in a Midwest paper mill.

- Design of an increased performance superheater for a Wood Fired Boiler.

- Consulting with US Industries, now Jacuzzi Products, (successor to Zurn Industries) to close outstanding contractual liabilities and in regard to asbestos litigation

- Consulting with the McBurney Corporation for the design of a wood fired boiler for a West Coast lumber mill and a rice hull fired boiler for Thailand. Performed combustion calculations, heat transfer design for the boilers and superheaters. Designed boiler circulation, steam separator and scrubber systems.

REPORT OF STUDY OF BOILER FACTORS
ATTACHMENT I - - CAREER PROFILE - - ROBERT V. SEIBEL

1967 to 1996 - Zurn Industries Inc., Energy Division, Erie, PA

The Zurn Energy Division (which continued as Aalborg Industries and Erie Power Technologies and now CMI and Indeck Keystone Energy) was a well-known designer, fabricator, and constructor of a wide range of fuel burning and steam generating equipment for industry.

Responsibilities included:

- Boiler and burner performance design and engineering on an individual basis and also group and department management levels.
- Sales and Marketing department management.
- Management of Field Service.
- Management of all technical forces including Engineering, Field Service and Computer resources.

Directed Engineering and Project Management of current contracts.

Participated in and was responsible for new product development and application and selling of existing products.

Investigated and resolved product performance issues.

Responsible for development of engineering standards and operating instructions.

Developed testing and evaluation programs for current and proposed technologies.

Oversaw the purchase and integration of new products and technologies.

Investigated and reported on incidents of boiler failure.

Presented deposition and trial testimony in several legal actions.

1954 to 1967 - Babcock and Wilcox Company, Barberton, OH

Babcock and Wilcox is one of the best- known suppliers of steam generating equipment for electric utilities and industry.

Responsibilities included:

- Field Service Engineering.
- Chemical Engineering for water treatment specific to all steam generating products.
- Design Engineering for pulp and paper industry products.

Individually responsible for boiler start up, performance testing and problem resolution.

Responsible for boiler water treatment issues for utility and industrial boilers.

Responsible for design aspects of current and evolving boiler and related products for pulp and paper.

Directed the start up and operator training of major utility steam generators and large industrial boilers.

Involved with the investigation of incidents of boiler damage.

Developed specific procedures for utility boiler water treatment and chemical cleaning.

Analyzed product performance problems.

REPORT OF STUDY OF BOILER FACTORS
ATTACHMENT 2 - - DEPOSITION TESTIMONY - - ROBERT V. SEIBEL

Deposition testimony, as the Zurn corporate representative, was given in the following actions all of which are claims of damage from asbestos containing materials against Zurn:

Date	Court	Plaintiff	Defendant	Case Number
October 17, 2002	Circuit Court of the Second Judicial District of Jones County, Mississippi	Charles Holder, et al	Westinghouse Electric Corporation, et al	No. 2000-134-CVS
January 13, 2004	District Court of the 23rd Judicial District Brazoria County, Texas	Howard Peterson	American Optical	CV23941*BH03
May 18, 2005	Third Judicial District Court for Salt Lake County, Utah	Howard and Nadine Sortor	Asbestos Defendants	040909899

REPORT OF STUDY OF BOILER FACTORS
ATTACHMENT 3 - - DOCUMENTS REVIEWED - - ROBERT V. SEIBEL

The Documents listed below were reviewed in preparation of this report.

Documents Reviewed and Studied	Document Bates Number
IKE's Complaint	
VEO's Answer, Affirmative Defenses and Counterclaim	
VEO's Second Amended Counterclaim	
IKE's Reply and Affirmative Defenses to Second Amended Counterclaim	
Keystone Engineering Design Guide	
Compact disc containing various boiler manufacturers' sales brochures	VEO 8822–VEO 9244
Transcript of deposition of Mark White, taken on February 1, 2006, pursuant to Federal Rule of Civil Procedure 30(b)(6), with deposition exhibits 16 through 25	
Miscellaneous e-mail between Darren Stephenson and Mark White	VEO 8205-VEO 8211
VEO water tube boiler computer software development term sheet	VEO 8079-VEO 8085
VEO rating software screen shots	VEO 8122-VEO 8123
Purchase Agreement between VEO and E-Tech, Inc.	VEO 8124-VEO 8139
Revisions to draft of Purchase Agreement between VEO and E-Tech	VEO 8141-VEO 8150
Voyager Series two page advertisement/brochure	
Printed pages from VEO website regarding Voyager Series boiler, dated January 28, 2006	
Miscellaneous documents, drawings and materials produced by Victory Energy	VEO 9396-VEO 9419 and VEO 9421-VEO 9697
Documents pertaining to Group Thermoboil's O Type Watertube Boiler	VEO 9420-VEO 9421
Drawings pertaining to the Voyager Series Boilers	VEO 13815-VEO 13866
Keystone Boiler Drawings	VEO 3503-VEO 3540
Spreadsheet Comparing Voyager Characteristics to Keystone M-Series	
Voyager Series Data Sheet	VEO 8183
Keystone Standard Data Sheets KDB 1.0, KDB 2.0, KDB 4.0, KDB 5.0, KDB 6.0, KDB 7.0, KDB 8.0 and KDB 9.0	
Max Ship Data for Keystone G.O. 1921	